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Brief Communication: Diet-Induced Changes in Rates of Human Tooth Microwear: A Case Study Involving Stone-Ground Maize

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Investigators have long felt that an emphasis on stone-ground grain in the diets of certain prehistoric and historic human populations may have led to accelerated tooth wear in those groups (Barrett, 1958; Dahlberg, 1963; Greene et al., 1967; Ruffer, 1920; Storey, 1976). Investigators have also suggested that rates of tooth wear are particularly high in cultures where maize is ground on stone tools made of relatively large-grained rocks such as sandstone (Leigh, 1937; Smith, 1972). However, because all human tooth wear occurs relatively slowly (compared with tooth wear in other animals), associations between rates of human tooth wear and diet have generally been documented through cross-sectional analyses rather than longitudinal studies. Thus correlations have been established between differences in the degree of faceting or the amount of dentin exposure and cultural differences in diet (e.g., Barrett, 1958; Campbell, 1925; Collins, 1932; Davies and Pedersen, 1955; Drennan, 1929; Goldstein, 1948; Hall, 1976; Hrdlicka, 1933; Kieser et al., 1985; Leigh, 1925a,b; Lunt 1978; Waugh, 1933). The only attempts at longitudinal studies (e.g., Beyron, 1964; Carlsson et al., 1985; Molnar et al., 1983a,b) have taken years to document accelerated rates of wear and have been ultimately forced to make comparisons with published estimates of "typical" rates of human tooth wear.

Recent analyses of microscopic wear patterns on teeth have shown that changes in dental microwear may be used as indicators of rates of tooth wear (Teaford, 1994; Teaford and Glander, 1991; Teaford and Oyen, 1989b,c: Teaford and Tylenda, 1991). Moreover, rates of wear can be documented in a matter of days, even in human populations from western industrialized societies. The purpose of this study was to see if a change in the rate of molar wear could be documented in one person (J.L.) who voluntarily added a large component of stone-ground maize to his diet.

Baseline dental impressions were taken 28 weeks apart using the techniques described by Teaford and Oyen (1989a). Between examinations, the subject maintained a normal American diet including many different food items. Immediately after the second baseline impression was taken, the subject changed his diet to include one large corn meal muffin with each meal each day. During the 1st week of this modified diet, the maize was solely that which had been custom-ground on sandstone grinding tools as those used by the Anasazi at Mesa Verde, Colorado. At the end of 1 week on the modified diet, another dental impression was taken. Immediately afterward, the subject's diet was again changed, this time to include large portions of a different form of stone-ground maize—that which had been ground on fine-grained, igneous grinding tools which are harder and produce less abrasives than do the sandstone tools. After 1 week on that modified diet, another dental impres-

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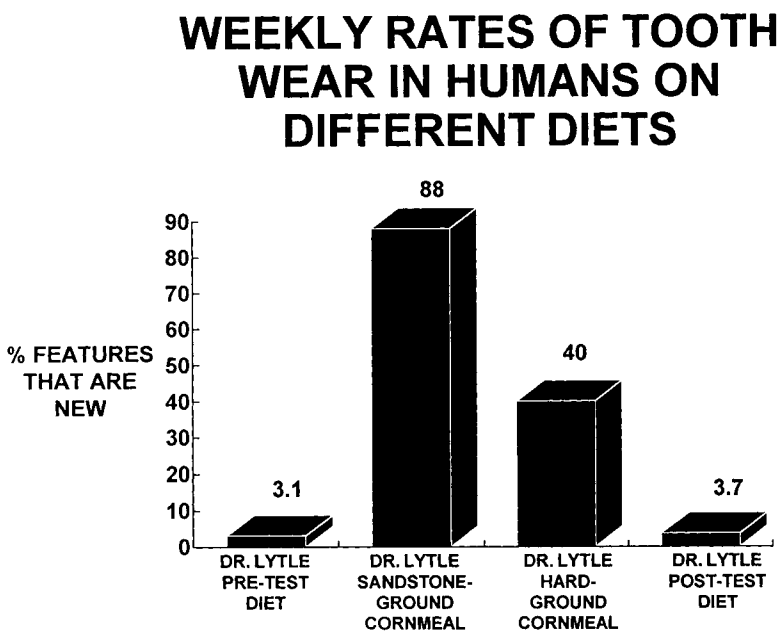

Fig. 1. Changes in rates of molar wear associated with changes in diet.

sion was taken, and the subject returned to his normal, pre-maize diet. Finally, 2 months after the last impression session, two more impressions were taken 1 week apart. During that 1-week period, the subject maintained his usual, pre-maize, diet.

Epoxy casts were made from each of the impressions using the techniques described by Teaford and Oyen (1989a), and the casts were examined in an AMRAY 1810 scanning electron microscope in secondary emissions mode. Two micrographs were taken of occlusal contact facets on M1 (facet 9, and the tip facet on the hypocone) (Kay, 1977) at a magnification of 200×. Rates of wear were calculated for four time periods: 1) the 28-week period of "normal" wear (before any modifications in diet), (2) the 1-week period including the sandstone-ground maize, 3) the 1-week period including the igneous-ground maize, and 4) the 1-week period subsequent to all diet modifications when the subject was once again on his normal diet. All calculations of rates of wear involved comparisons of micrographs taken of exactly the same areas for baseline and follow-up casts during the period of interest. As in previous work (Teaford and Glander, 1991; Teaford and Oyen, 1989b,c; Teaford and Tylenda, 1991), the following three-step procedure was used to calculate rates of wear:

1. The number of microwear features in the follow-up micrograph was counted;
2. The number of "new" features (i.e., those not visible in the baseline micrograph) was noted;
3. The number of new features ("2" above) was divided by the total number of features ("1" above) to yield the percentage of microwear features created between baseline and follow-up.

Rates of wear obtained for facet 9 and the hypocone tip facet were averaged together. As three of the four time periods were 1 week long, the rate calculated for the initial period was divided by 28 to yield an estimated baseline, weekly rate of wear.

As can be seen from Figure 1, the extrapolated weekly rate of wear for the initial 28-week period was very similar to the rate of wear obtained during the 1-week period at the end of the study. By contrast, the rate of wear during the week on sandstone-ground maize was approximately 30 times that dur-

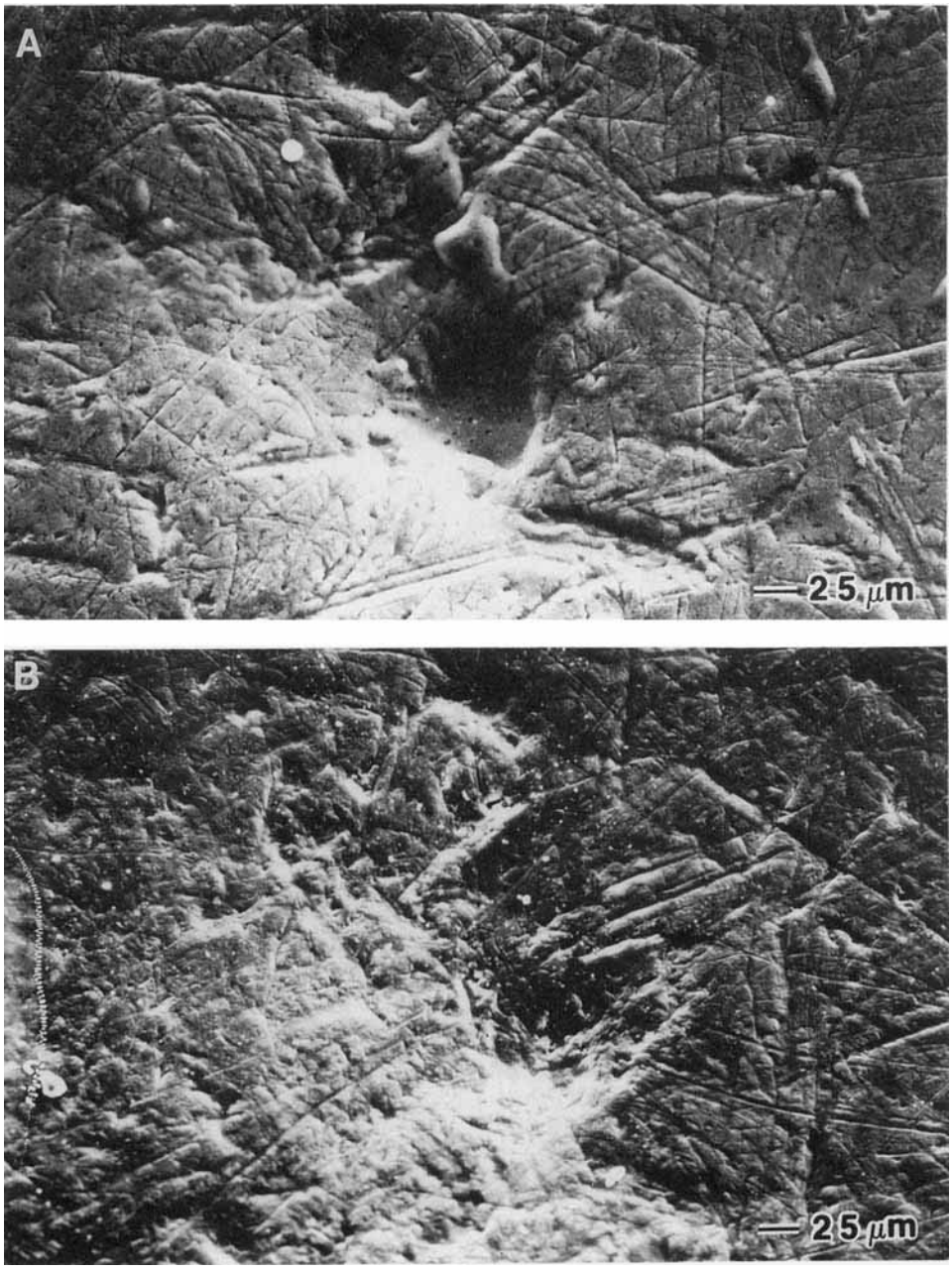

Fig. 2. **A:** Baseline micrograph of M^1 (February 3, 1994). **B:** Follow-up micrograph of same surface (February 10, 1994).

ing either period on the subject's normal diet (see Fig. 1). The rate of wear during the week on the igneous-ground maize was not as great as that during the week on the sandstone-ground maize, but it was still 13 times higher than that during the subject's normal diet (see Fig. 1).[1]

As can be seen in Fig. 2, the main change in microwear during the weeks on either maize diet involved an increased amount of microscopic scratching on the teeth.

Five points should be evident from this brief study. First, the rates of tooth microwear during the subject's normal diet are similar to, or slightly lower than, those documented for other samples of American dental patients (Teaford and Tylenda, 1991). Second, the accelerated rates of tooth wear during the modified diets are much greater than those during the subject's normal diet. In fact, the rates during the modified diets are similar to those documented for laboratory monkeys raised on hard diets (Teaford and Oyen, 1989c), or for wild-caught monkeys from a tropical dry forest habitat (Teaford and Glander, 1991). Third, the differences in rates of molar wear between the periods on sandstone-ground and igneous-ground maize, respectively, suggest that differences in food-processing techniques may well lead to differences in rates of tooth wear. Fourth, if the average depth of microwear features is estimated at 1–2 μm, and the high rates of wear (i.e., 100% turnover in dental microwear in 8–18 days) continued for a large portion of the individual's lifetime, the net effect would be an annual rate of wear (on the facet in question) ranging from 20 to 90 μm per year (depending on which method of grinding is used). Fifth, if average enamel thickness on human molars is 1–2 mm (i.e., 1,000–2,000 μm), such rates of wear would be sufficient to obliterate the enamel on a molar wear facet in as little as 10–15 years.

This is essentially a case study of one individual. Rates of wear may vary between individuals in different test conditions. For instance, the amount of stone-ground maize in the diet of prehistoric or historic human populations might well have been more than that used here, increasing the rate of wear. Likewise, if individuals habitually ground their teeth at night (unlike the subject here), the rates of wear might well have been higher. It may even be that the presence of extra abrasives in the mouth could *promote* grinding (Enbom et al., 1986; Goldhaber and Goldberg, 1954; Lytle, 1990, 1993; Pöllmann et al., 1987). However, the key point here is that the results of this study, despite its limitations, confirm that a diet incorporating significant amounts of stone-ground maize can indeed lead to accelerated rates of tooth microwear.

[1]The computation of the rate of wear focuses on the number of microscopic features created between baseline and follow-up impressions. Thus scratches created in the previous week (while the subject was eating the sandstone-ground maize) had no effect on the rates of wear computed for this week.

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